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A PROGRAM OF ION SOURCE RESEARCH AND DEVELOPMENT

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OVERALL PROGRESS

Recent source design modifications have improved ionization efficiency and power input to levels above 99% at 60-70 ev/ion at ion flow rates of about 1.6 amperes. Two simple distribution probes have been built and tested to demonstrate the effectiveness of the concepts involved. The design of a more versatile and accurate probe is presently being drafted. Major modifications to the vacuum system have been completed to facilitate more rigorous instrumentation. Two simple sources have been tested for distribution to identify broad problem areas, and a series of sources for further testing have been built. During the period 4-1 thru 4-28-63, 526 man-hours have been applied to this program.

HARDWARE

A series of ion source/expansion devices are shown in Figs. 1-4. The simple nozzle shown in Fig. 1 utilized a boron nitride nozzle to insure that the arc passed through the entire cross section of the plasma, from the hollow cathode to the external ring anode. Fig. 2 shows a design built to investigate the effect of an axial electrode on ionization and power input. Fig. 3 is a series of multiple fuel passage sources, designed to gather empirical data on the effect of multiple directed streams, the type of distribution from relatively long thin tubes, and the effect of nozzle half angle on beam spreading and cutoff. These devices have not been tested. The source shown in Fig. 4 was designed from an approximate analytical study conducted under another contract. Here the annular nozzle is directed outward to aid rapid beam spreading, the conical nozzle is designed to provide cutoff of the beam, and the rounded plug to allow dispersion toward the center.

Figs. 5, 6, and 7 are informal sketches of distribution probes. The first two are interim devices, rapidly designed and built to demonstrate feasibility and to provide rough distribution data. The third probe combines the best points of the first two, and in addition is mounted on a sliding, rotating shaft for examination of the beam over a wide range of position. This device is presently in drafting.

The original vacuum system for this program was an 18" diameter bell jar with a hemispherical glass end; all penetrations were through one steel plate which blanked off the open end of the bell jar. This has been replaced with an 18" diameter pyrex cylinder 15" long, and a second steel backplate with provision for multiple penetrations has been fabricated. This modification will permit downstream placement of all mounting and electrical connections to beam measuring devices. A rough sketch is shown in Fig. 8.

EXPERIMENTAL RESULTS

Ionization and Power Efficiency

With the source sketched in Fig. 1, a series of tests were run to optimize the placement of the ring anode. The results are shown in Fig. 9, and can be interpreted as follows: the apparent increase of total flow (a) as measured by direct titration of the probe contents, with decreasing electrode gap is due to ion interception and scattering by the anode. When the anode is further downstream, it intercepts a larger faction of the flow, and at least some of these particles never reach the probe as either ions or neutrals. The increase in ionization with decreasing electrode gap can also be explained by anode interception, since some of the scattered ions will be neutralized and eventually reach the cold probe as neutrals. These results, which are accurate to better than $\pm 1\%$, represent satisfactory source performance for the present, and emphasis for the immediate future is placed on plasma expansion. Tests with Source II did not result in increased efficiency.

Expansion of Plasma

With the source shown in Fig. 1 and the probe shown in Fig. 5, an experiment was run to determine roughly the distribution to be expected from a simple converging-diverging nozzle. The results are approximately represented by a $\cos^{12}\Theta$ distribution, where Θ is the angle from the beam axis. This distribution is entirely unsatisfactory, peaking sharply along the beam axis and retaining only 67% of the beam between the 3:1 density limits.

Source II (Figure 2) was run with the same probe and gave results approximated by a $\cos^3\Theta$ or $\cos^4\Theta$ distribution. This distribution is still too sharply peaked along the axis, and in addition retains only 25%-30% of the total flow within the 3:1 density limits.

The main difficulty in these tests is the lack of precision and versatility of these first probe designs, and the time necessary to analyze a run. Both obstacles should be overcome when the probe shown in Fig. 7 is put into operation.

Accelerator Tests

Some preliminary ion acceleration tests have been performed under Contractors Independent Research and Development Funding which are pertinent. Accelerator work to be performed later under the present contract will undoubtedly rest heavily on the ground work now being laid, and it is intended that these monthly reports relay briefly the overall progress of this phase of the work.

Accelerator results pertinent to the present contract are incomplete to date, but beam acceleration has been observed with a plasma expanded from a high density source of the type described above. A high accelerator impingement rate and inability to hold rated voltage are problems presently being pursued. The detailed results have not yet been published, and will be referenced in a later report.

PLANS FOR NEXT MONTH

The sources shown in Figs. 3 and 4 (10 combinations) will be tested for plasma expansion with the double plate probe (Fig. 5) until the improved probe is completed. Installation of the improved probe and more detailed distribution tests will follow.

A qualitative study will be made of the necessary elements of a good expansion device, based on experimental and analytical approximations, and the analytical study of the aerodynamic expansion device will be initiated.

Some flux plotting and/or electrolytic tank devices will be studied to confirm or modify the present computer designed accelerator.

Figure 1

Source Design I

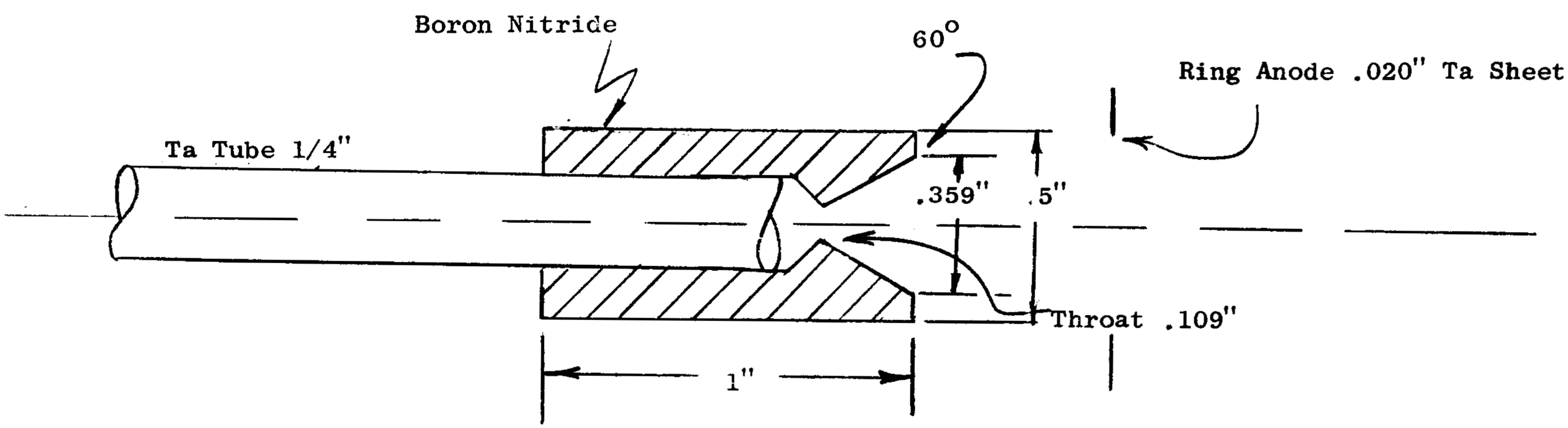


Figure 2

<u>Source Design II</u>

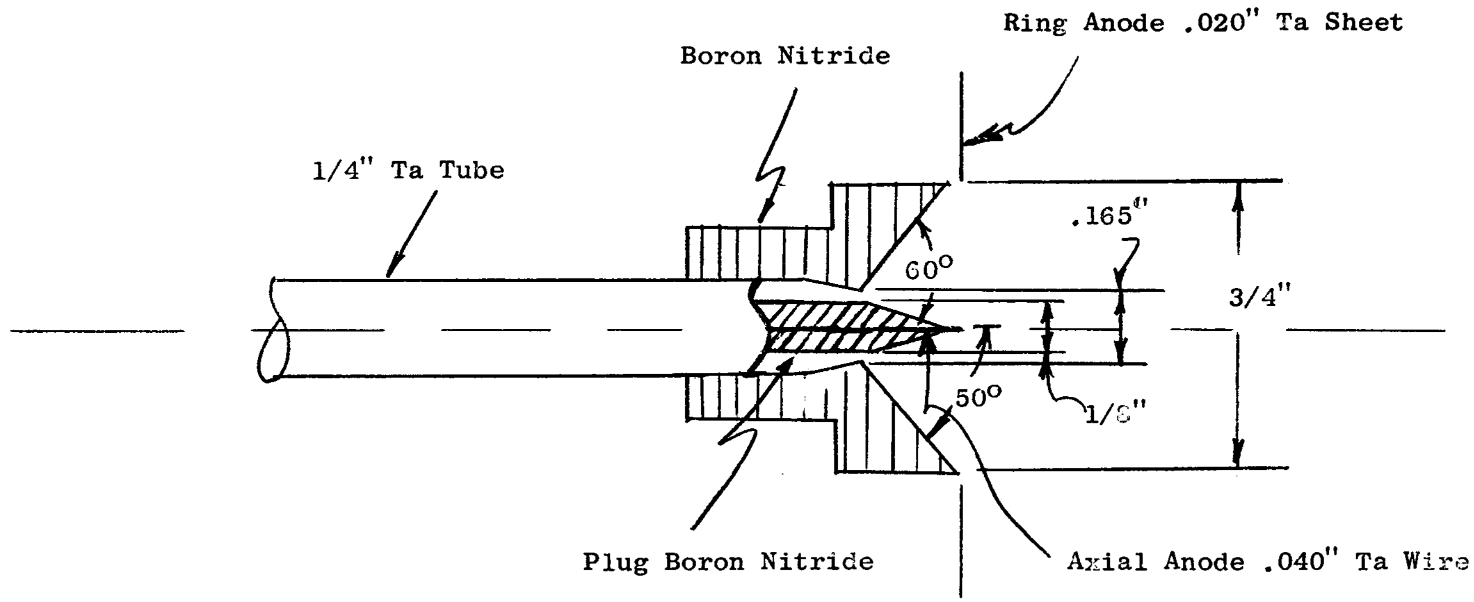


Figure 3

Source Design #IV, V, VI

		θ	β
Noz. IV	(a)	15°	15°
	(b)	20°	15°
	(c)	25°	15°
Noz. V	(a)	20°	20°
	(b)	25°	20°
	(c)	15°	20°
Noz. VI	(a)	25°	25°
		20°	25°
		15°	25°

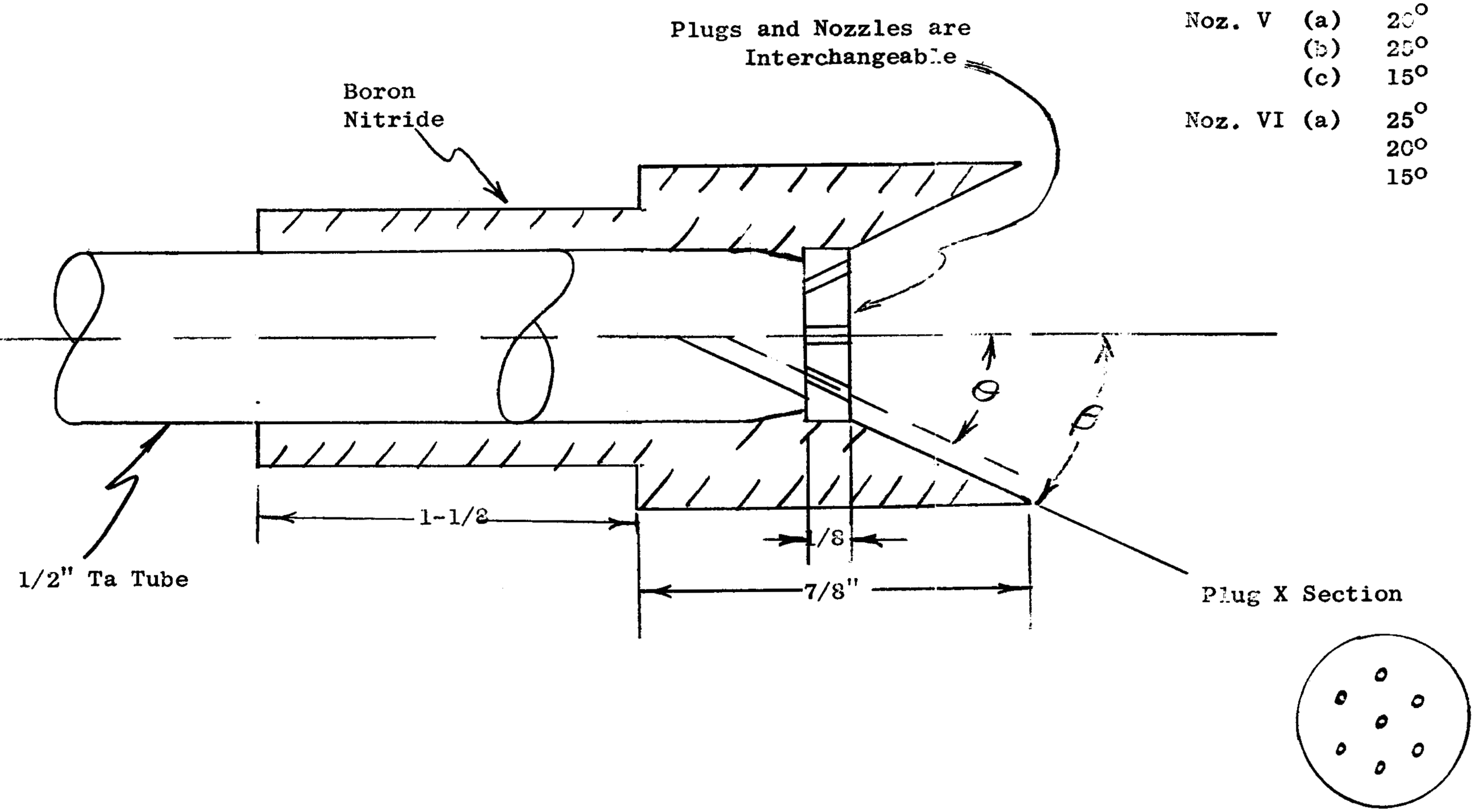


Figure 4

Source Design III

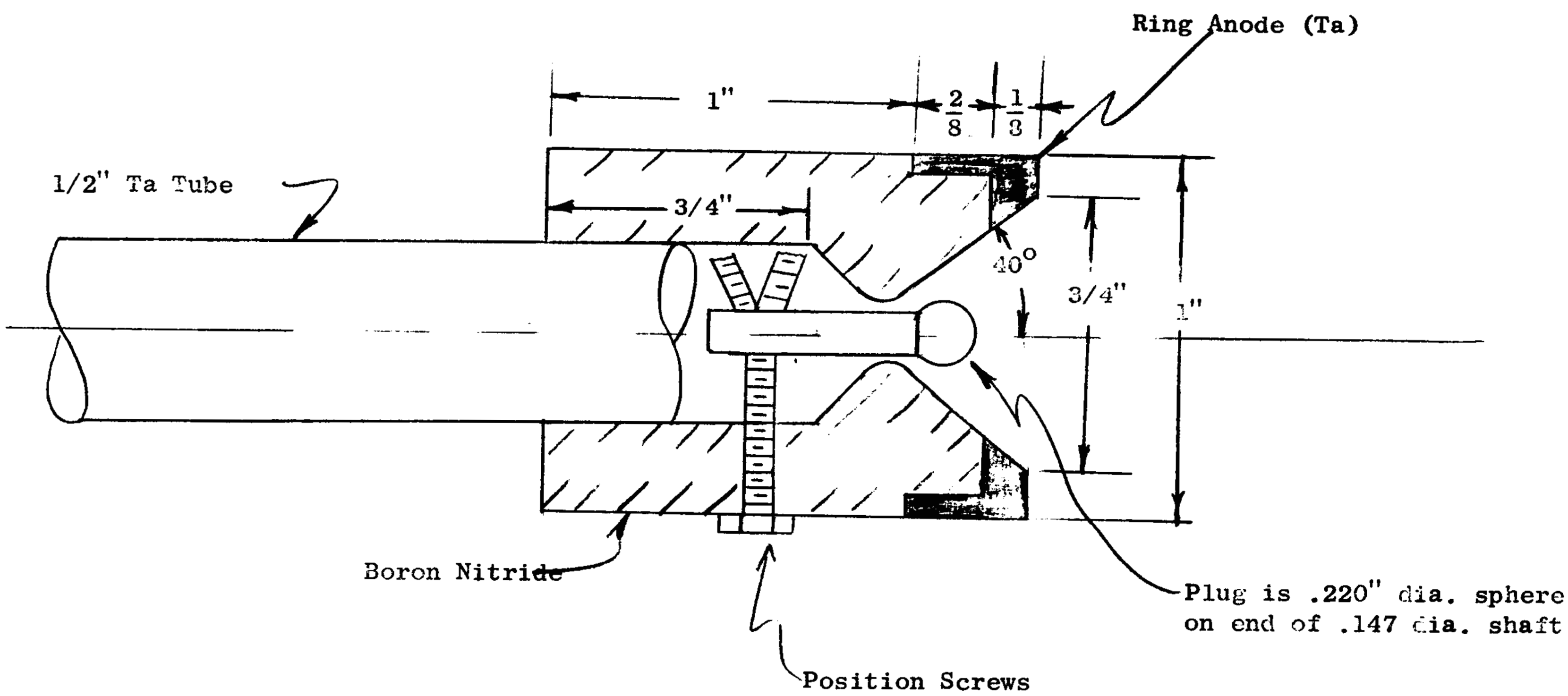


Figure 5

Double Plate Distribution Probe

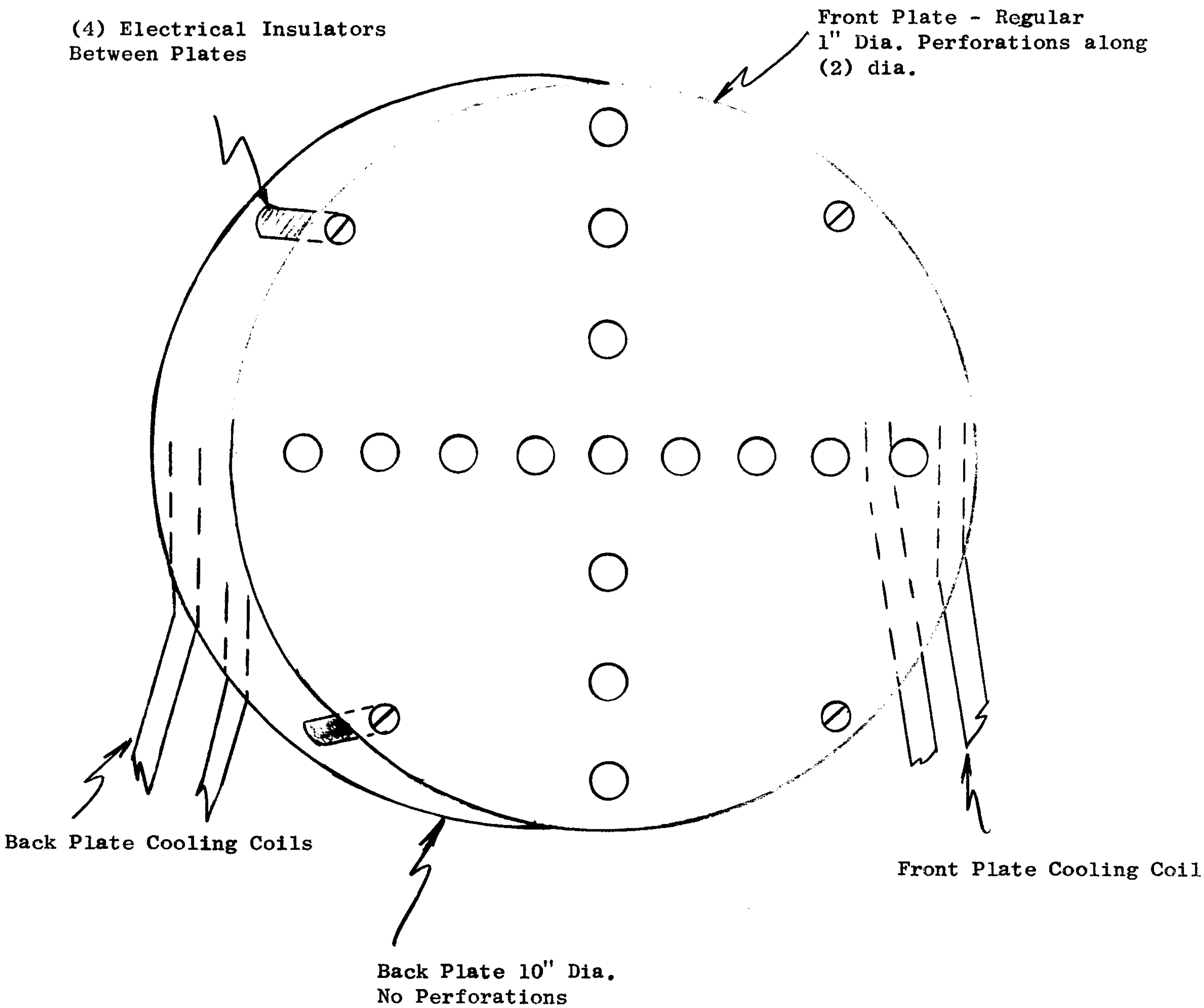


Figure 6

Nineteen Point Ion Probe

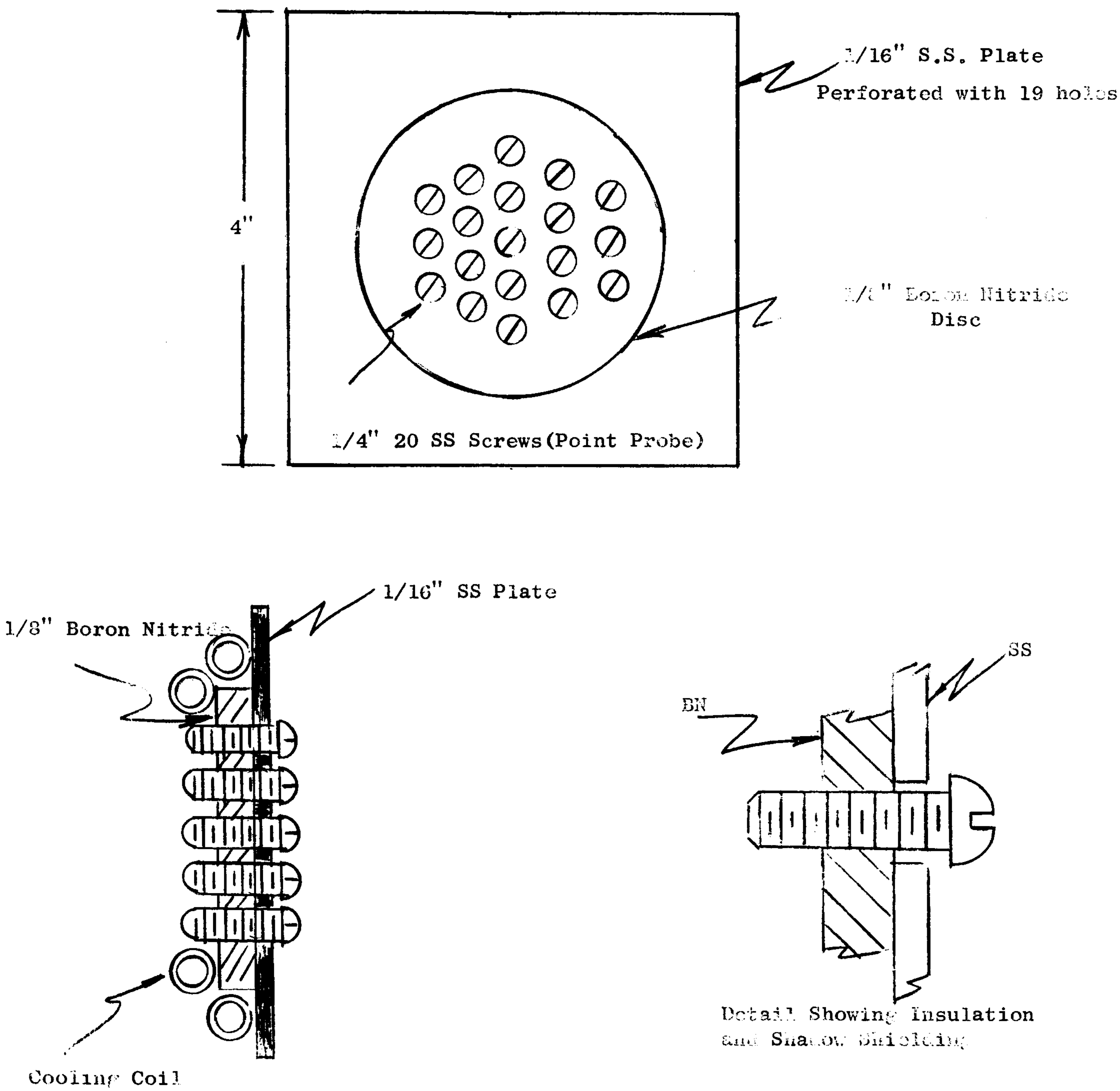


Figure 7

Improved Distribution Probe

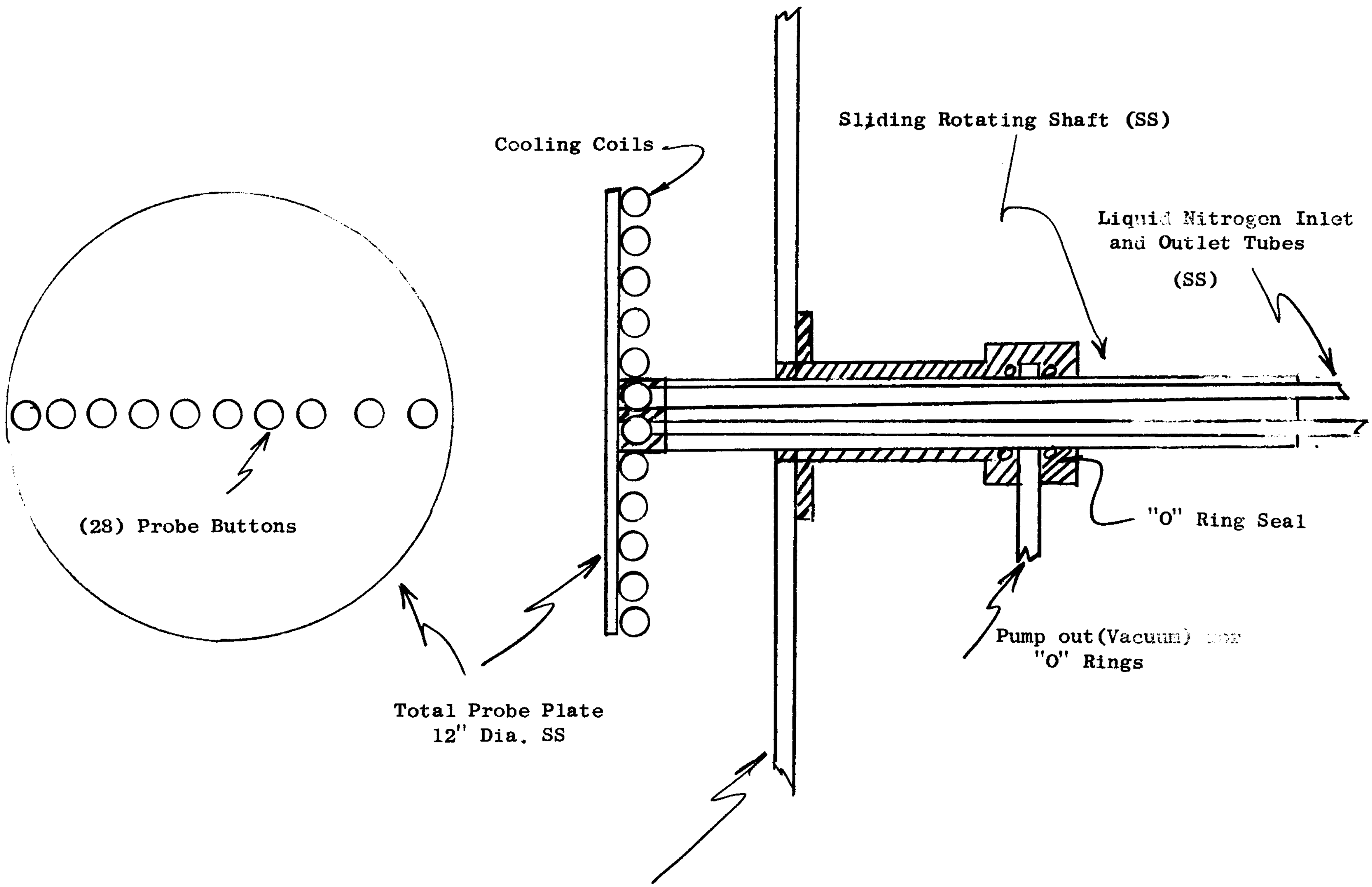
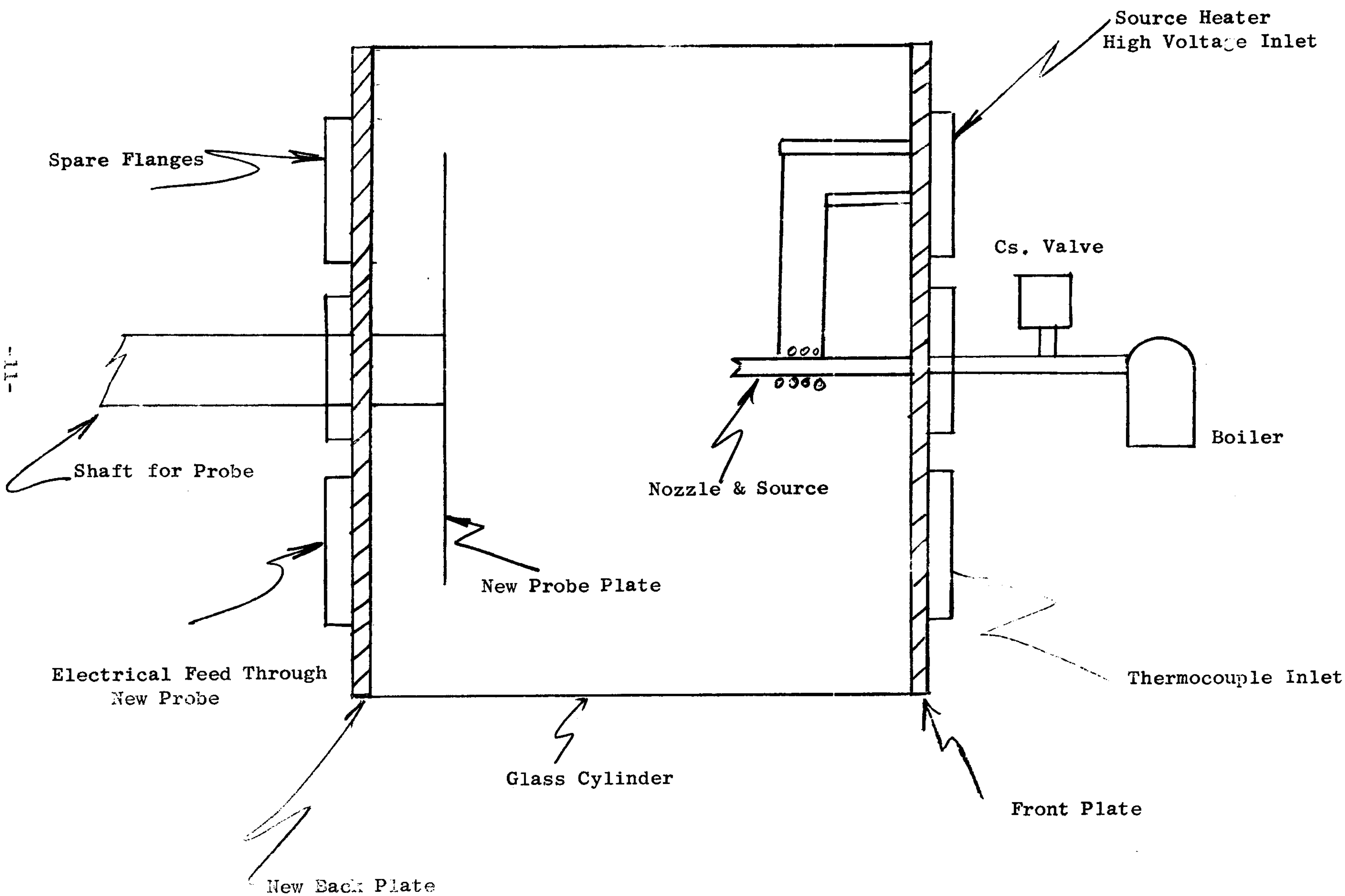


Figure 8

Modified Vacuum System



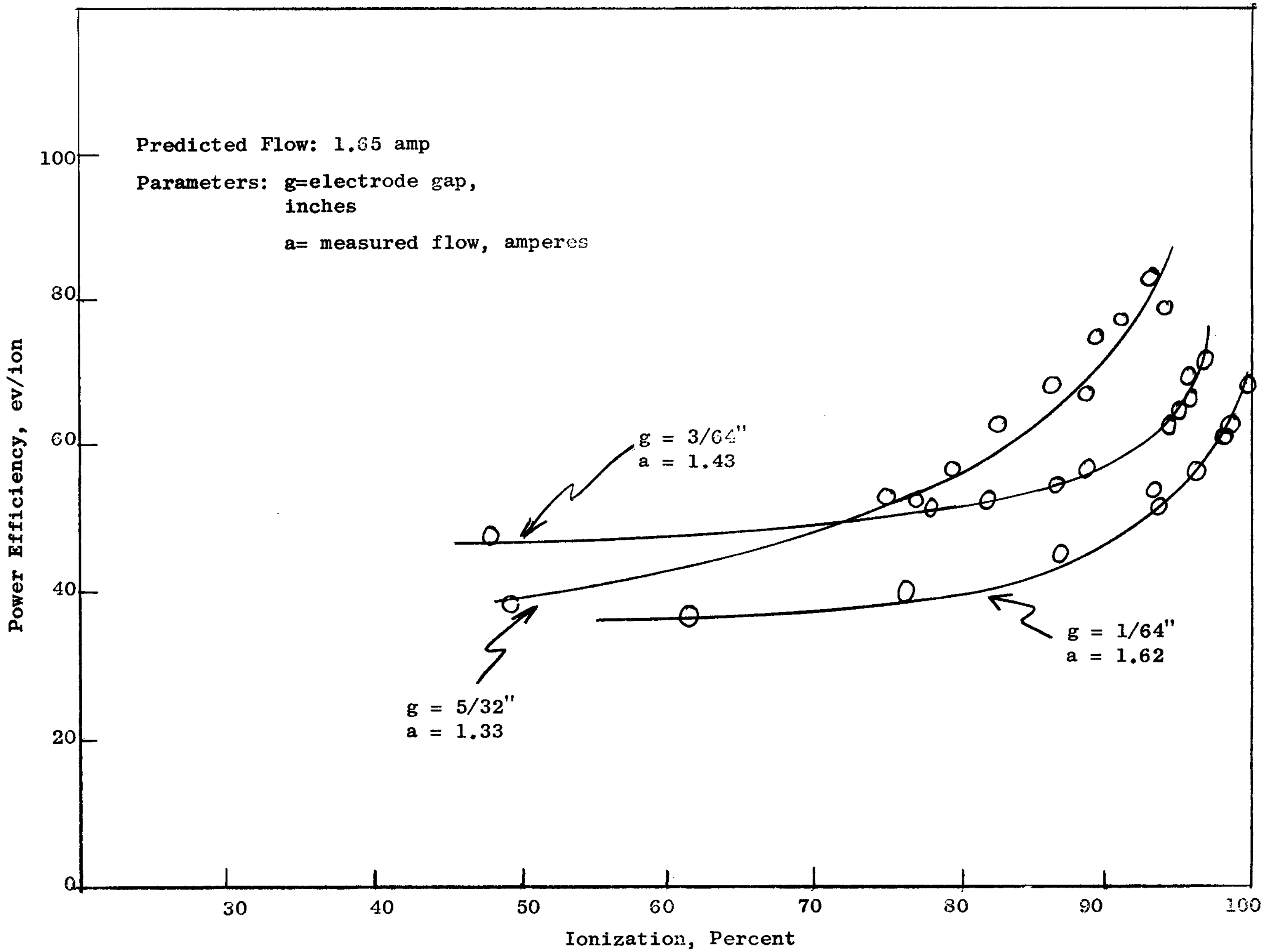


Figure 9: Power Efficiency Vs. Ionization

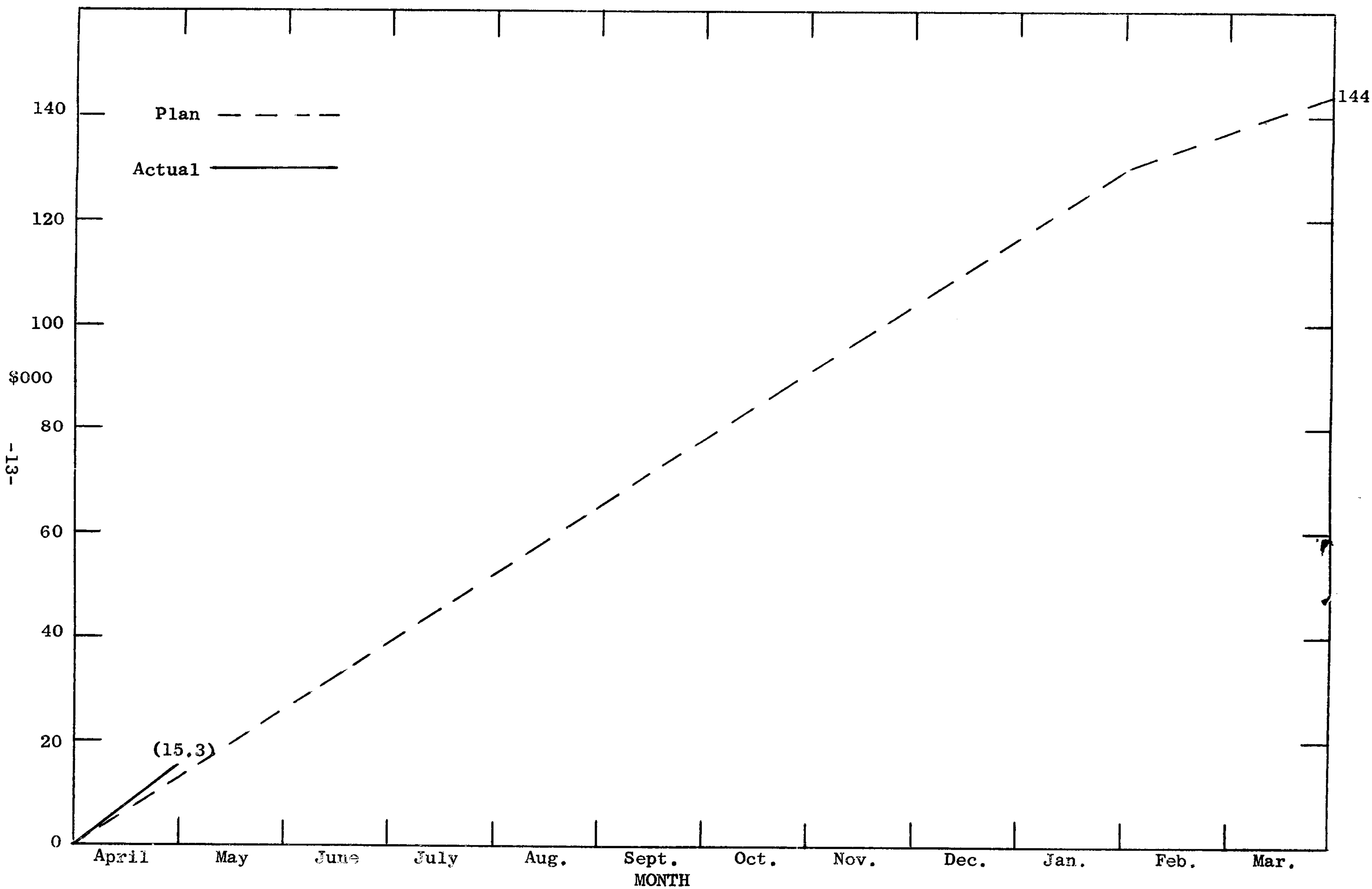


Figure 10: Planned Vs. Actual Expenditure